

Student Reference

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Student Reference 1: Safety

The first step in ensuring a safe learning environment is to read over the entire procedure before you begin any activity in the science classroom. Make sure you note and understand the safety cautions. If you are unsure about any procedure or safety instruction, ask your teacher before you proceed.

Safety Icons

You will be alerted to safety hazards in *Addison Wesley Science 10* by the following symbols. Look for them at the top of the *Materials and Equipment* section of each activity.

TABLE 1.1 Safety Icons

	glassware; breakage hazard
	eye protection required
	protective clothing required, such as lab apron
	protective gloves required

Safety Symbols

Some safety information is given by standard symbols on the product label. There are two main groups of labels: those for hazardous household products and those for hazardous workplace products.

Household Hazardous Product Symbols (HHPs)

Labels on hazardous household products must include a symbol that indicates the degree and type of hazard. The shape of the symbol tells you about the degree of hazard (Figure 1.1). A red octagon shape means “danger,” an orange diamond shape means “warning,” and a yellow triangle means “caution.” The symbol inside the shape tells you the type of danger.



FIGURE 1.1 If the toxic symbol was in a yellow triangle, what would the hazard symbol mean?

Workplace Hazardous Materials Information System (WHMIS)

Hazardous materials used in the workplace (including classrooms) must be labelled according to the WHMIS. These symbols are similar to those of HHPs, but WHMIS symbols also identify additional hazards (Figure 1.2). These symbols are used in *Addison Wesley Science 10*. Look for them in the *Materials and Equipment* section of each activity. You will find the appropriate WHMIS symbol beside any hazardous material that will be used.

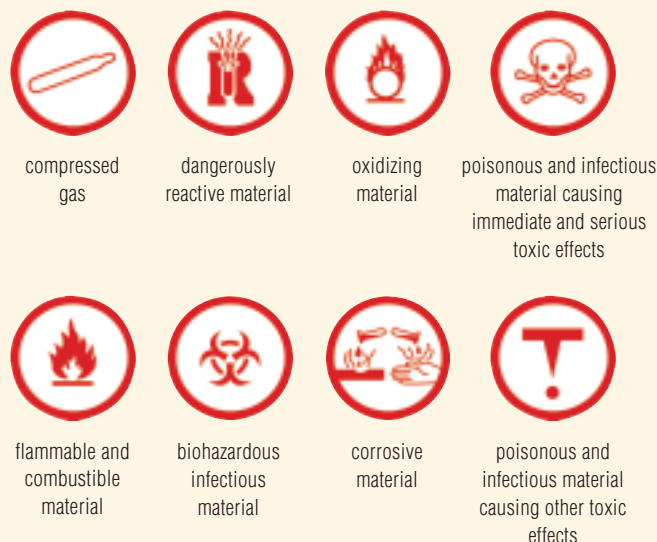


FIGURE 1.2 Make sure you understand the meaning of the symbol before you proceed with any activity.

Suppliers of hazardous workplace products must also provide a materials safety data sheet (MSDS). The MSDS gives detailed information about the potential hazards of a chemical. The MSDS must be stored in an accessible place. An example of an MSDS appears on page 9 of *Addison Wesley Science 10*.

Laboratory Safety Practices

This section provides general guidelines to help you work safely in the science classroom. Your teacher may provide additional instructions specific to your school.

1 General Safety Procedures

- a) Identify and locate all safety equipment.
- b) Know how to operate all safety equipment.
- c) Wear appropriate safety apparel, as indicated in the activity.
- d) Tie back long hair. Remove or secure any loose clothing.
- e) Obtain the approval of your teacher before starting any procedure, especially one you have planned independently.
- f) Never work alone or without your teacher's supervision.
- g) At the end of all lab activities, make sure your work space is clean.
- h) Wash your hands after completing any lab work.

2 Bunsen Burners and Hot Plates

- a) Never leave a Bunsen burner or hot plate unattended.
- b) Before connecting a Bunsen burner, make sure the gas supply valve is completely closed. Open the valve just slightly, then immediately light the Bunsen burner.
- c) Be sure to use only heatproof containers.
- d) Use tongs or holders to handle all hot objects.

3 Glassware

- a) Never use chipped, cracked, or broken glassware.
- b) Place all broken glass into a marked container, as instructed by your teacher.
- c) Use the glassware specified in the procedure, unless instructed otherwise by your teacher.
- d) Ensure glassware is clean before and after use.

4 Chemicals

- a) Read the safety precautions provided on the label before using any chemical. Never use a chemical from an unlabelled container.
- b) Never smell, taste, or touch chemicals in the laboratory without your teacher's instruction.
- c) Never directly inhale fumes. To smell a substance, waft the air above it toward your nose.
- d) Never return unused chemicals to stock bottles or containers.
- e) Dilute acids by adding **acid to water**. Add the acid slowly, by pouring it down the side of the container.

5 Electrical Devices

- a) Keep water and wet hands away from electrical cords.
- b) Never use electrical equipment that has a damaged plug or wires.

What if an accident occurs?

If an accident occurs, inform your teacher right away. Any injury, no matter how small, must be reported. Any spills or breakages must be cleaned up only under the direction of your teacher.

Student Reference 2: The Inquiry Process

Science is a way of asking questions about the world, and then answering these questions using a structured approach. This is sometimes called the inquiry process. It uses logical reasoning to find answers to questions, through observation, measurement, experimentation, research, analysis, and evaluation.

The proposed answer to a question about a scientific problem or issue is called a hypothesis. An experiment is a way of testing to see if a hypothesis should be accepted or rejected. Experiments are designed so that only one variable (a condition that can change in an experiment) is modified at a time. All other variables are controlled (kept unchanged). The effect of the variable that is modified is observed and recorded, and then the observations are analyzed and interpreted. The experimenter then decides whether the observations support the hypothesis, and then clearly communicates the results and conclusions.

STEP 1 Ask a question.

The inquiry process starts when you ask a question. In the inquiry process of science, questions are often about cause and effect. Suppose you leave a glass of ice water in sunlight. You observe that the ice seems to melt more quickly than when you leave an identical glass of ice water in the shade. If you wanted to use the inquiry process to explore this observation, you might ask a cause-and-effect question like the one below. In this example, the cause is the exposure to sunlight and the effect is the rise in temperature of ice water.

How does exposure to sunlight affect the temperature of ice water?

STEP 2 State a hypothesis.

A hypothesis is one possible explanation of an observed phenomenon. When you propose a hypothesis, you are predicting the answer to the question you have asked. The hypothesis is often stated as an “if ... then” statement. To be useful, a hypothesis must be testable. A testable hypothesis will predict observable and/or measurable changes in one variable as a result of modifications to the manipulated variable. A hypothesis about the effect of sunlight on ice water could be

If ice water is exposed to sunlight, then its temperature will increase over time at a greater rate than it would if the ice water was kept in the shade.

Step 1: Ask a question.

- Formulate a question about a scientific problem or issue.

Step 2: State a hypothesis.

- A hypothesis is a reasonable answer to the question.

Step 3: Design the experiment.

- Identify the variables.
- Write a design statement.
- Write a procedure that describes how to test the hypothesis by manipulating one variable.
- Identify and prepare for any safety hazards.
- Select appropriate instruments and equipment.

Step 4: Carry out the procedure.

- Carry out the procedure, ensuring that only one variable is changed at a time.
- Use suitable tools and materials appropriately and safely.
- Work as a team to address problems.

Step 5: Collect and record data.

- Observe and record the necessary data.

Step 6: Analyze and interpret the data.

- Determine the relationships between the variables. When possible, use tools such as graphing or mathematical calculations.
- Compare experimental and theoretical values, and account for any differences.
- Identify sources of error.

Step 7: State your conclusions.

- State whether the hypothesis is accepted, based on the interpretation of the results.
- Identify new questions or problems.

The hypothesis clearly states what will be tested (the rate of temperature change of ice water in sunlight versus in shade). It also must relate the cause (exposure to sunlight) to only one effect (increase in temperature over time). A hypothesis may also predict that the manipulated variable will not affect the responding variable. This would be a null hypothesis, which is a hypothesis that states there is not a relationship between the variables being tested. Since the experiment will be designed to test the hypothesis, it does not matter if the hypothesis is accurate or not. However, it should be a reasonable prediction of the expected results of the experiment.

STEP 3 Design the experiment.

An experiment is a set of changes made by an experimenter and/or specific observations that test a hypothesis. When designing an experiment, the first step is to identify all the variables that could affect the outcome of the experiment. For example, the following variables could affect the outcome of an experiment to find the effect of sunlight on ice water: exposure to sunlight, the length of time of exposure, the volume of the ice water, the proportion of ice to water, the length of time over which observations are made, the type of container in which the ice water is held, and the starting temperature of the ice water.

Once all the variables are identified, the next step is to decide which variable will be changed, which ones will remain the same, and which variable will be measured or observed in order to test the hypothesis. A manipulated variable is a condition that is deliberately changed by the experimenter. A controlled variable is a condition that could change during an experiment but does not, because of the actions of the experimenter. A responding variable is a condition that changes in response to the change in the manipulated variable. When a cause-and-effect question is being investigated, the responding variable corresponds to the effect predicted in the hypothesis.

Manipulated variable: *exposure to sunlight*

Controlled variables: *the volume of the ice water, the proportion of ice to water, the type of container in which the ice water is held, and the starting temperature of the ice water*

Responding variable: *the temperature of the ice water*

Variables in an experiment may also be independent or dependent variables. An independent variable is any variable that influences the effect being studied, but is not itself affected by the experimental conditions. For example, time is the independent variable in this experiment. A dependent variable is any variable that is influenced by changes in the independent variable, under the conditions of the experiment. The dependent variable is therefore the same as the responding variable.

Independent variable: *time*

Dependent variable: *the temperature of the ice water*

Once all the variables have been identified, write a design statement for the experiment. The design statement outlines the general plan for testing the hypothesis and identifies all variables. It also identifies the conditions of the experimental control. An experimental control is a set-up that includes all the conditions of the experiment, except that the manipulated variable is not changed. In this example of the ice water experiment,

the beaker that is left in the shade (is not exposed to sunlight) is the experimental control.

Design Statement

Identical volumes of ice water will be placed in two different locations, one of which will be in the sunlight, and the other in the shade. The temperature of both ice water samples will be recorded every 2 min. Exposure to sunlight is the manipulated variable, and the temperature of the ice water is the responding variable. The ice water that is left in the shade will be the experimental control. Controlled variables are the volume of ice water, the proportion of ice to water, the type of container used, and the starting temperature of the ice water. Time is the independent variable, and the temperature of the ice water is the dependent variable.

The procedure of an experiment describes how the manipulated variable will be changed, how the controlled variables will be kept unchanged, and how the responding variable will be observed and recorded. A procedure is usually written as a series of numbered steps that can be easily followed.

Procedure

1. *Make a data table to record the temperature of two samples of ice water every 2 min for 10 min.*
2. *Prepare 300 mL of ice water in a 500-mL beaker, by mixing approximately equal amounts of water and crushed ice.*
3. *Measure 100 mL of ice water into each of the 250-mL beakers.*
4. *Using a thermometer, measure and record the starting temperature of each sample.*
5. *Place a stirring rod into both ice water samples. Place one sample in direct sunlight, and the other in the shade. Stir each sample throughout the procedure.*
6. *Every 2 min, measure and record the temperature.*
7. *Continue to take readings for 10 min.*

The experimental design must outline any safety hazards and how they will be handled. Refer to *Student Reference 1: Safety* for more information. The experimental design must also list all the materials and equipment that will be needed. A diagram may be used to illustrate how equipment is to be set up.

Safety

*Do not use the thermometer to stir the ice water.
Be careful handling any glassware.*

Materials and Equipment

<i>crushed ice</i>	<i>1 100-mL graduated cylinder</i>
<i>500 mL water</i>	<i>2 thermometers</i>
<i>1 500-mL beaker</i>	<i>2 stirring rods</i>
<i>2 250-mL beakers</i>	<i>timer</i>

STEP 4 Carry out the procedure.

Put on any protective clothing, goggles, and gloves required, and collect the necessary equipment. Carefully follow the steps of the procedure, making sure that only the manipulated variable is changed. Divide tasks among your group members.

STEP 5 Collect and record data.

As the experiment progresses, observations related to the independent variable and the responding variable must be clearly recorded. Dependent on the experiment, an observation may be based on qualitative data, which is information that does not involve measurements of amounts. For example, an experiment on the rate of photosynthesis of two aquatic plants might include qualitative data on the colour of each plant (e.g., red or green). Qualitative data should be recorded in complete sentences. Qualitative data may also be recorded as a scientific diagram. Refer to *Student Reference 8: The Compound Light Microscope*, for details on how to draw a scientific diagram.

Observations may include quantitative data, which is information that involves measurements of amounts. Quantitative data must always include the units used to make the measurements. It is often organized in a data table, clearly labelled with a title. The independent variable is listed in the first column, and the units of measurement are clearly identified. The responding variable is listed in the next column. The data table below shows how one student recorded the quantitative data for the ice water experiment.

Observations

Temperature of Ice Water Samples over Time

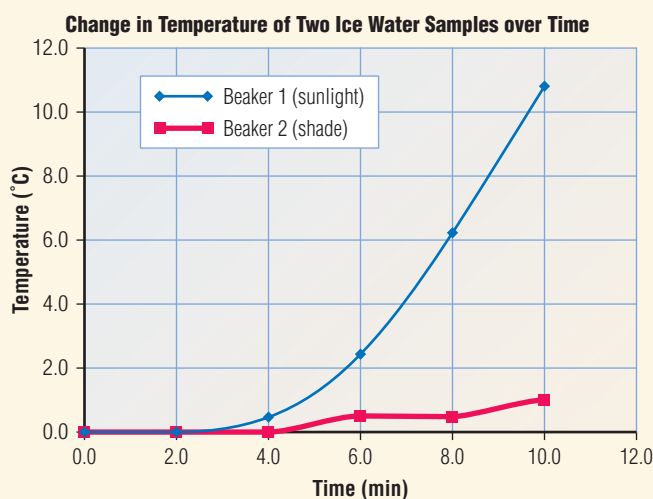
Time (min)	Temperature (°C)	
	Beaker 1 (sunlight)	Beaker 2 (shade)
0.0	0.0	0.0
2.0	0.0	0.0
4.0	0.5	0.0
6.0	2.4	0.5
8.0	6.3	0.5
10.0	10.8	1.0

All quantitative measurements must be recorded to the correct number of significant digits. You can find more information about this in *Student Reference 5: Measurement*. An experimenter should also note any unusual or unforeseen events that occur during the course of the experiment. For example, if a thermometer breaks and you have to change thermometers, you must record this fact.

STEP 6 Analyze and interpret the data.

There are many ways of analyzing data. For example, you might compare an experimental (empirical) value to a theoretical (calculated or accepted) value and calculate the percent error. You can find more information about percent error in *Student Reference 6: Math Skills*. A common way of analyzing quantitative data is to create a graph. For example, the difference in the rate of temperature change can be seen more clearly in a scatterplot or line graph. *Student Reference 7: Graphing* provides details on drawing and interpreting graphs.

Analysis



From the graph of the temperature data, it can be seen that after about 4 min, the temperature of a sample of ice water exposed to sunlight was always greater than that of an identical sample kept in the shade. The temperatures of both samples increased over the course of the experiment, but the temperature changed more in the ice water exposed to sunlight. The relationship between temperature and time was non-linear for both samples.

Sources of Error

Analysis of the results must also include the sources of error. One source of error is the variation that always occurs when an experiment is repeated, even though the experimenter follows a well-designed procedure carefully and works with properly functioning equipment. This error is mainly due to the limits in the precision (reproducibility) of the particular instrument used to take the measurements and in its readability. More information about precision and readability of instruments can be found in *Student Reference 5: Measurement*. Scientists always repeat an experiment several times, which helps to reduce the effect of this source of error. In the science classroom, you may not always be able to repeat your experiment. However, you can get a sense of the accuracy of your results by comparing your data with those of your classmates, or with theoretical values.

Another source of error can occur when a measuring instrument has not been properly calibrated. Calibration is the process of comparing the measurements given by the instrument against known standards, and ensuring that the two values match. If an instrument is not properly calibrated, the measurements taken with that instrument will always contain an error. Professional scientists therefore calibrate their instruments regularly. These sources of error can be avoided.

Finally, error may result if there is a flaw in the design of the experiment or in how the procedure was carried out. When an experiment is affected by this source of error, the relationship between the manipulated and responding variables will be unclear. If this occurs, re-examine the procedure and ensure that there were no unidentified variables that may have affected the results. For example, if a cloud covers the Sun during the ice-water experiment, then a new variable is introduced. In cases such as this, the experiment must be repeated, or redesigned to control the additional variable.

The sources of error in this experiment include the readability and precision of the thermometer, the graduated cylinder, and the timer used to make measurements. Between 3 min and 4 min, a cloud covered the Sun, which introduced an uncontrolled variable during this period.

STEP 7 State your conclusions.

The conclusion of an experiment states whether the hypothesis is accepted, based on the interpretation of the results. After the conclusion, outline any unresolved questions or new problems that could be investigated, based on these results.

Conclusion

These data support the hypothesis that if ice water is exposed to sunlight, then its temperature will increase more quickly than when ice water is kept in the shade. Based on this experiment, it would be interesting to test if the rate of temperature change varies according to the amount of thermal energy added to the ice water.

You may be required to communicate the results of your experiment in a lab report. Refer to *Student Reference 11: Writing Reports*, for additional information.

Student Reference 3: The Problem-Solving Process

Technology is the application of scientific knowledge to solve practical problems. For example, a pair of scissors is a piece of technology that uses scientific knowledge about wedges and levers to solve the practical problem of making clean cuts in certain substances. Developing a technology to solve a problem follows a series of general steps.

STEP 1 Recognize a practical need.

This step involves recognizing a practical need that can be addressed by a technological solution. For example, say you are about to go on a camping trip. The park service has issued an extreme fire hazard warning, so campfires are not allowed. You have to walk to the camping area, so you cannot carry in water. The need in this situation is that you must purify lake water so that it is safe to drink.

STEP 2 Identify the specific problem to be solved.

When you understand the situation, you can then restate the problem in terms of a specific task. Campers can usually purify lake water by boiling it over a campfire. In this situation, however, the problem is how to purify water without using a campfire. The task is to construct a device that will purify water by some other means.

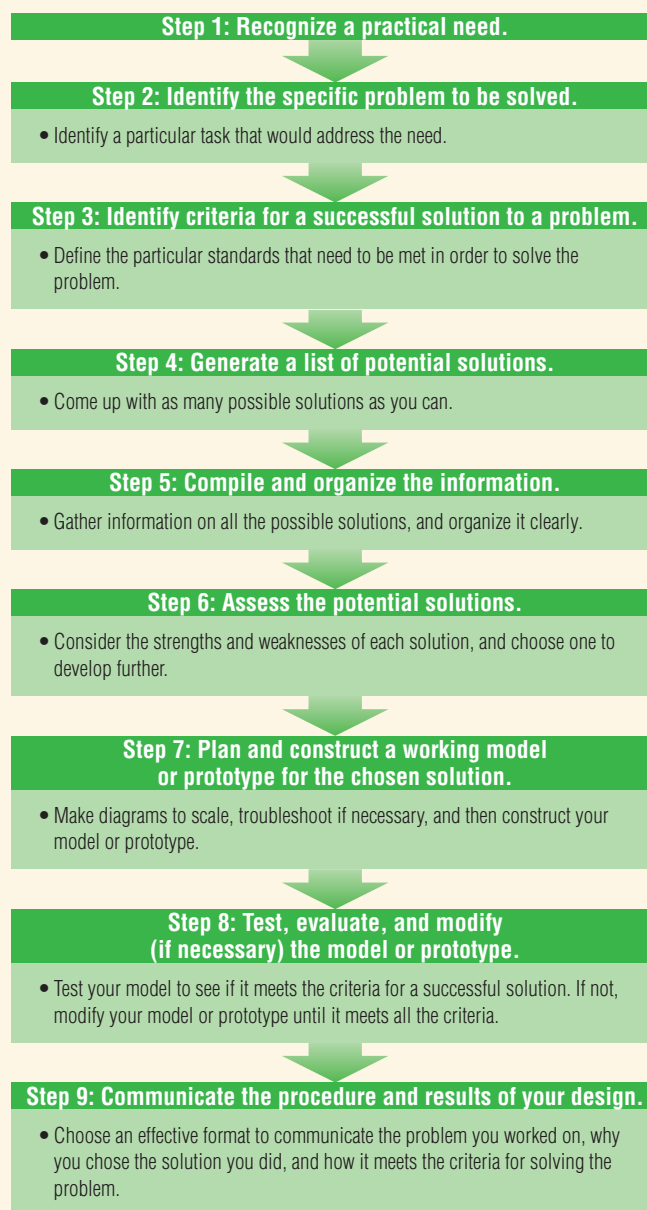
STEP 3 Identify criteria for a successful solution to a problem.

Assessment criteria are a set of conditions that will tell you when and if you have solved the problem successfully. Establish these before you carry out any in-depth research, planning, or analysis of the problem. When you are setting criteria for success, you must consider limits to your possible solutions. Limits may include cost, time, safety, social implications, environmental impact, and feasibility. For a school assignment, the criteria may be set by you or your teacher.

For example, the criteria for the device in the water purification example would include: it will remove all harmful micro-organisms, it will not require a campfire, and it will be made of materials that can be carried into or found at a remote campsite.

STEP 4 Generate a list of potential solutions.

Brainstorming and/or conducting research are key components of this step. Brainstorming involves generating as many ideas as possible without judging them. Record your ideas clearly.



Here are some of the ideas that one group of students came up with for solving the problem of purifying water without a campfire:

- a device that converts solar energy to thermal energy
- a device that converts the chemical energy in candles to thermal energy
- a device that filters out micro-organisms

STEP 5 Compile and organize the information.

Conduct research to collect information on each idea. You might need to use library and electronic research tools, interview experts, or visit business sites. Generate a list of materials and equipment needed for each solution.

As you collect the information you need, organize it in a form that allows you to clearly see any links or gaps in your information. Continue your research until you can no longer identify any gaps. Refer to *Student Reference 9: Researching Information* for more details on finding and organizing information.

STEP 6 Assess the potential solutions.

You will now need to use the information you have found to choose one idea to develop further. Decide on a method for analyzing the information you have collected. Graphic organizers can be very helpful for sorting information. *Student Reference 10: Tools for Analyzing Information* provides a number of examples you may find useful. Each of these tools can be modified to fit the specific information you are analyzing.

Based on your analysis, assess the potential strengths and weaknesses for each possible solution. Determine whether you can get all the necessary materials and equipment for each solution. If cost is part of the criteria for your potential solution, then calculate the cost of each idea as well. Finally, choose one possible solution that you think is most likely to meet all the criteria.

STEP 7 Plan and construct a working model or prototype for the chosen solution.

Start a plan for a working model or prototype for the solution you have chosen. You will likely need to create a working diagram on paper or using computer software. You may need to make several diagrams as you identify and solve problems in the design. This allows you to explore and troubleshoot your ideas early on. Your diagram should include detailed labels and a scale, similar to a blueprint. Have your teacher approve your plans before you build your model.

Models are useful for presenting a three-dimensional view and for testing the operation of the design. Your design may need to be modified at any step before the final model is constructed.

STEP 8 Test, evaluate, and modify (if necessary) the model or prototype.

Testing allows you to check how your solution works. If you find a problem during testing, you can then make modifications to your design and test the model or prototype again. Invite your classmates and your teacher to try your design. Their feedback can help you identify things that could be improved, and they may be able to offer some ideas of their own.

Finally, make sure you return to your original list of criteria for solving the problem. Check your model or prototype against the list, and make sure you have truly met your original goals.

STEP 9 Communicate the procedure and results of your design.

Choose an appropriate way to clearly communicate the problem, why you chose the solution you did, all the details of building and testing your model or prototype, and how well your solution meets the criteria for solving the problem. Possible choices include presenting your model or solution as a display, making an oral presentation that includes a demonstration of your model, or writing a report. *Student Reference 11: Writing Reports* provides more details about preparing a report.

Student Reference 4: The Decision-Making Process

Making good decisions involves gathering relevant information, considering the information, and then making a choice based on that information. In many decisions you will make, some of this information will involve scientific knowledge. Many decisions will also require consideration of the potential impact of your decision on other people or events, and that you balance your views with the perspectives of others. Decision-making can be organized into a series of steps, as shown in the flowchart on this page.

STEP 1 Define the practical problem or issue.

A practical problem is a real-world difficulty that requires action. An issue is a controversy that needs to be resolved. The first step in the decision-making process is to identify questions that arise from practical problems or issues. Based on these questions, make a clear statement that defines the problem or issue. In the example below, an issue is defined first by a question and then a statement.

Should the City of Calgary build a waste disposal site to the west of the city, near the Kananaskis Valley?

The City of Calgary is proposing that a waste disposal site be located close to the Kananaskis Valley.

STEP 2 Identify the viewpoints.

To make an informed decision, you must identify and describe all the related viewpoints. These can be scientific, technological, social, or economic. Consider the issue from the perspective of different stakeholders as well. Stakeholders are people who are affected in some way by the issue or practical problem. Viewpoints that may be considered include:

- Scientific—scientific facts and theories
- Ecological—protection of the natural environment
- Technological—design and use of technology
- Health and safety—well-being of people
- Social—human relationships, public welfare, or society
- Cultural—customs of a particular group of people
- Educational—sharing and acquiring new skills
- Ethical—beliefs about what is right and wrong
- Aesthetic—beauty in art and nature
- Historical—knowledge dealing with past events
- Recreational—leisure activities
- Political—effects of the issue on government policies
- Economic—financial and business issues

Step 1: Define the practical problem or issue.

- Ask a question about a practical problem or issue.

Step 2: Identify the viewpoints.

- List the major points that need to be considered, including who in society will be affected by the decision.

Step 3: Conduct research.

- Find information related to the major points and record it clearly.

Step 4: Analyze the information.

- Assess the information, including any limitations of data or bias in interpretation. Weigh the costs and benefits of all potential courses of action or decisions.

Step 5: Propose a course of action or a decision, and justify your choice.

- Suggest one course of action to solve the problem, or come to a decision about the issue. Use the results of your research to justify your choice.

Step 6: Communicate your decision.

- Share your decision with others, and be able to defend that decision with the information you researched.

The following example outlines some of the viewpoints that a student identified concerning the waste disposal issue:

- *Environmentalists may object to a waste disposal site on the grounds that it could have a negative impact on the ecology of the Kananaskis Valley.*
- *Business leaders may consider this proposed project to be an advantage for their businesses, since they could be involved in supplying the site with materials needed for its construction and operation.*

STEP 3 Conduct research.

Conducting research involves activities such as using library and electronic research tools, interviewing people, and taking a field trip. The aim is to get as much information as possible on each of the viewpoints you identified in Step 2. It is important to evaluate your sources of information to determine if there is a bias, and to separate fact from opinion.

Make sure you keep a record of the resources you use and the information you found in each. *Student Reference 9: Researching Information* provides additional guidance on finding and recording information and information sources.

STEP 4 Analyze the information.

Decide on a method for analyzing the information you have collected. Graphic organizers can be very helpful for sorting information. *Student Reference 10: Tools for Analyzing Information* provides a number of examples you may find useful. Each of these tools can be modified to fit the specific information and issue you are analyzing.

In the example here, the student ranked each potential consequence by its importance. Each was given a number to designate the ranking: high (3), moderate (2), low (1), or none (0). Each consequence was then designated either negative (a cost) or positive (a benefit).

Cost/Benefit Analysis of Proposed Waste Disposal Site

<i>Potential Consequence</i>	<i>Importance (3,2,1,0)</i>	<i>Cost or Benefit?</i>
<i>ecosystems destroyed</i>	<i>2</i>	<i>cost</i>
<i>run-off</i>	<i>3</i>	<i>cost</i>
<i>residents affected by traffic</i>	<i>2</i>	<i>cost</i>
<i>disposal site well used</i>	<i>3</i>	<i>benefit</i>
<i>economic opportunities from construction and operation</i>	<i>2 to 1</i>	<i>benefit</i>

STEP 5 Propose a course of action or a decision, and justify your choice.

Based on your analysis, make a decision on the issue or propose a solution to the practical problem that you believe will have the most positive and the least negative consequences. Ensure you have considered the viewpoints of all the stakeholders. (In some cases in *Addison Wesley Science 10*, you will be asked to consider the viewpoint of only one type of stakeholder.)

When proposing your course of action or decision, refer to any facts and figures you found during your research. For example, here is part of what one group of students considered in proposing a course of action regarding the waste disposal site:

Building a waste disposal site near to the Kananaskis Valley would likely cause environmental harm, and would therefore have a great deal of opposition. Instead of going ahead with this site, a study should be conducted to determine the effects of locating the waste disposal site to the east of the city.

STEP 6 Communicate your decision.

Choose an appropriate way to communicate the issue, the decision or proposal you made, and your justification. Possible choices include participating in a debate, writing a letter to a newspaper, creating a poster or Web page, or writing a report. *Student Reference 11: Writing Reports* provides more details about preparing a written report.

Student Reference 5: Measurement

Scientific investigations may involve collection of measured quantities, or quantitative data. A measurement always consists of a number and a unit. The unit tells us what is being measured.

The International System of Units

To communicate clearly, scientists use a system of units called SI (short for *Système International d'Unités*). SI has seven base units (Table 5.1)

TABLE 5.1 Base Units of SI

Quantity	Unit Name	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
temperature	kelvin	K
electric current	ampere	A
luminous intensity	candela	cd
amount of substance	mole	mol

Derived units are units that are combinations of the base units. Table 5.2 lists four derived units that you will encounter during your Grade 10 studies.

TABLE 5.2 Derived SI Units

Quantity	Unit Name	Symbol	Definition
volume	cubic metre	m ³	m ³ = m·m·m
pressure	pascal	Pa	Pa = kg/m·s ²
force	newton	N	N = kg·m/s ²
energy	joule	J	J = kg·m ² /s ²

For very large or very small quantities, all SI units are modified by decimal divisions, following the conventions of the metric system. The particular division used is indicated by adding a prefix to the base unit or derived unit. Some prefixes and their symbols are shown in Table 5.3.

TABLE 5.3 Common SI Prefixes

Prefix	Symbol	Value	Scientific Notation
giga-	G	1 000 000 000	10 ⁹
mega-	M	1 000 000	10 ⁶
kilo-	k	1000	10 ³
hecto-	h	100	10 ²
deka-	da	10	10 ¹
deci-	d	0.1	10 ⁻¹
centi-	c	0.01	10 ⁻²
milli-	m	0.001	10 ⁻³
micro-	μ	0.000 001	10 ⁻⁶
nano-	n	0.000 000 001	10 ⁻⁹
pico-	p	0.000 000 000 001	10 ⁻¹²

Non-SI Units

Some non-SI units are commonly used along with SI units in science. Non-SI units that you may see in your Grade 10 studies are shown in Table 5.4.

TABLE 5.4 Non-SI Units

Quantity	Unit Name	Symbol	Definition
time	minute	min	1 min = 60 s
	hour	h	1 h = 3600 s
	day	d	1 d = 86 400 s
	year	y	1 y = 31 557 600 s
area	hectare	ha	1 ha = 10 000 m ²
volume	litre	L	1 L = 1000 cm ³
mass	metric ton or tonne	t	1 t = 1000 kg
temperature	degree Celsius	°C	0°C = 273.5 K